Appendix A: Complete methodology for the Town of Philipstown GHG baseline inventory

Production-based Accounting: Data Collection and Calculations

Transportation and mobile sources

I. On-road transportation:
We used the USCP (United States Community Protocol) to estimate the following for the transportation factor set in ClearPath for both gasoline and diesel-fueled vehicles: passenger, motorcycle, light truck and heavy truck fuel efficiency (MPG; miles per gallon); CH_4/mi emitted; and N_2O/mi emitted. We used the 2009 New York State (NYS) Department of Transportation (DOT) Mobile CO Emissions Factors for Project-Level Microscale Analysis to estimate the percentages of vehicle type on Philipstown's roadways: 47.6% gasoline passenger vehicles, 0.5% motorcycles, 43.2% gasoline light trucks, 4.0% gasoline heavy trucks, 0.1% diesel passenger vehicles, 1.0% diesel light trucks and 3.7% diesel heavy trucks. There is no transit fleet operating within Philipstown boundaries.

The NYS DOT issues the Roadway Inventory which classifies roadways, provides length of each classification segment within the jurisdiction, and an estimate of the annual average daily traffic (AADT) on that segment. We secured DOT data for Philipstown and the Villages of Cold Spring and Nelsonville. By multiplying road segment lengths by AADT, we get vehicle miles traveled (VMTs) daily.

The vast majority of local road classifications (functional classes 9 and 19) within Philipstown do not have AADT counts in the DOT dataset, therefore the dataset is favoring larger roadways (with lower FC classifications), which have more traffic but do not characterize the within boundary traffic that occurs on our smaller, local roadways. In order to estimate AADT on FC9 and FC19 roadways in Philipstown, Cold Spring and Nelsonville, we averaged the AADT for all FC9 and FC19 roadways, respectively, in Putnam County. We then applied these county-average AADT estimates to each of Philipstown's, Cold Spring's and Nelsonville's FC9 and FC19 roadways.

Totaling the AADT counts within the jurisdiction resulted in daily VMT of 279,898.8, or a total annual VMT of 102,163,054.7.

II. Off-Road Transportation
The *Mid-Hudson GHG Inventory* used 2007 numbers (for a 2010 proxy) on off-road vehicle emissions using the U.S. Environmental Protection Agency's NONROAD emissions model. Emissions are reported for Putnam County. Philipstown residents represent 9.71 percent of Putnam County residents (9,674 of a 99,670 population for the whole of Putnam) in 2010. The County CO_2 emissions were reported at 36,752 metric ton carbon-dioxide equivalent (MTCO2e). This inventory attributes 9.71 percent of the total, 3,567 MTCO2e, to Philipstown.

III. Rail Transportation
Philipstown's jurisdiction includes a rail line on its western border along the Hudson River that carries Amtrak and Metro-North rail services. This inventory assumes freight rail as negligible (a freight rail line runs on the western bank of the Hudson River). In order to calculate emissions for these services, we estimated the total miles of rail service per year, the total gallons of fuel used in these trips and ultimately, the metric tons of CO_2-equivalent.

The rail track distance in Philipstown is 10 miles. Amtrak diesel train-miles per year in 2002 equaled 86,960 miles and total diesel fuel used was 224,190 gallons (Table 2-9, p. 2-13). Metro-North diesel train-miles per year in 2002 equald 283,185 miles along the Hudson Line (Table 2-12 p. 2-16). This inventory uses Table 2-13, p. 2-17 to estimate 3.34 gallons per train-mile, resulting in 945,837.9 gallons of diesel fuel used for the Metro-North service in Philipstown.

Adding total fuel use from both Amtrak and Metro-North service in Philipstown results in 1,170,027.9 gallons of diesel used per year of rail service within Philipstown's jurisdiction. Fuel usage was converted to CO_2e estimates using ICLEI's ClearPath tool.

IV. Water Transportation
Philipstown's western boundary is the Hudson River. Commercial boats pass through the Philipstown portion of the River and there is a ferry that departs Garrison Landing in Philipstown to West Point Military Academy across the River to Orange County. This ferry is in operation from April through May and from August through October and operates on Fridays, Saturdays and Sundays only, running continuous service throughout the day with no set schedule (but usually runs from Garrison Landing when a Metro-North train arrives nearly hourly (approximately 12 round-trip trips daily). We were not able to obtain actual data on the West Point ferry service line mileage or gallons of fuel consumed, so we used the Mid-Hudson Greenhouse Gas Inventory (2010) to estimate emissions. The MHGHG assigns marine off-road emissions to Putnam County at 26,650 MTCO2e. Since all of Putnam's shoreline is in Philipstown, we will use this metric as Philipstown's GHG emissions.

PHILIPSTOWN INVENTORY REPORT | 2020 | APPENDIX A

V. Air Transportation
There is no airport located within Philipstown's jurisdiction, so this inventory considers zero emissions from air travel originating from within Philipstown geographic boundaries.

Stationary Fuel Combustion: Residential and Commercial

I. Electricity
To calculate total emissions from residential electricity use, we used data from the 2016 NYS Utility Energy Registry (UER) for Central Hudson Gas & Electric Corporation for the municipalities of Philipstown, Cold Spring and Nelsonville (since the latter two are villages within the boundaries of Philipstown, but are not included in the UER's total for Philipstown). We then applied emissions factors from Central Hudson's electricity profile to calculate total emissions:

SOURCE	PERCENTAGE
Coal	4%
Oil	< 1%
Gas	43%
Nuclear	34%
Hydro	12%
Biomass	<1%
Wind	3%
Solar	< 1%
Renewable Biogas	<1%
Solid Waste	3%

Emission rates came out to the following, based on the above fuel percentages:

EMISSION TYPE	CENTRAL HUDSON EMISSION RATES (lb/MWh)
CO_2	519.68
CH_4	0.03472
N_2O	0.00448
CO_2e	521.808

We used the same methodology to calculate commercial electricity as we did for residential electricity described above, except we used the commercial totals instead.

II. Methane (Natural gas)
No utility methane sales currently are available in Philipstown for residential or commercial, so we were able to skip this emissions source.

III. Wood
To determine emissions from all for heating sources besides electricity, we first had to make some General Heating Fuels Housing Occupancy Adjustments using housing statistics from the 2016 American Community Survey (ACS) for Philipstown and NYS:

Philipstown Occupancy = 3599 (occupied units) / 4280 (total units) = 84% housing occupancy rate.
Occupied Single Family Detached (OSFD) = .84 x 3392 = 2851 houses
Occupied Single Family Attached (OSFA) = .84 x 201 = 169 houses
Occupied Multi-Family (OMF) = .84 x 685 = 575 houses

Once we estimated the number of occupied units in each category we then applied a weighted energy use average for each type of housing unit to calculate our Adjusted Housing Units (HUadj):

Adjusted Housing Units (HUadj) = ((108 MMBTU per year / 108) x 2851) + ((89 / 108) x 169) + ((54 / 108) x 575) = 3278
Philipstown HUadj percentage = 3278 / 3599 = 91.08%

We then repeated this step using state averages from the 2016 American Community Survey in order to calculate the NYS HUadj and HUadj percentage:

NYS Occupancy = 7,266,187 / 8,191,568 = 88.7%
OSFD = 3,043,600
OSFA = 360,506
OMF = 3,861,814
HUadj = 5,271,589
NYS HUadj Percentage = 5,271,589 / 7,266,187 = 72.55%

Now that we had HUadj percentages for both Philipstown and NYS, we could create a ratio to use state heating fuels data to estimate Philipstown heating fuels data for each heating source.

So, for Residential Wood in Philipstown we took the number of households heating with wood from the 2016 American Community Survey for both NYS and Philipstown and multiplied them by the HUadj percentages:
First we took the number of households heating with wood from the 2016 American Community Survey for both NYS and Philipstown and multiplied them by the above HUadj percentages:

NYS HUadj Wood = 144,316 x 0.7255 = 104,701 heating with wood
Philipstown HUadj Wood = 165 x 0.9108 = 150 households heating with wood

Then we calculated the total Wood Use in Philipstown by setting up the following ratio:

Wood Use NYS (taken from the U.S. Energy Information Administration's 2016 Fuel Use Data for NYS) / (NYS HUadj Wood x NYS Heating Degree Days) = Wood Use Philipstown (what we are calculating) / (Philipstown HUadj Wood x Philipstown Heating Degree Days)

Thus, Total Philipstown Wood Use = 13.4 Trillion BTU (Wood Use NYS) / 1,000,000 MMBTU/ Trillion BTU x (150 (Philipstown HUadj Wood x 5517 (Philipstown HDD) / (104,701 (NYS HUadj Wood) x 5642 NYS HDD) = 18,772 MMBTU

This total was then entered into ICLEI's ClearPath calculator to convert the amount of wood used into GHG emissions. The same was done for each of the following heating fuel sources.

For commercial heating fuels, we had no local fuel usage data. We first determined the total square footage of commercial space in Philipstown and NYS. For Philipstown we obtained the total Philipstown commercial square footage from the Town Assessor's Office. For NYS, we multiplied the total workers in NYS (2016 County Business Patterns - American Factfinder) by the national average (since we couldn't find a state average) square feet per worker (2012 EIA Commercial Building Energy Consumption Survey) to calculate the total NYS commercial square footage.

Total workers in Philipstown = 1904 workers (2016 Zip Code Business Patterns - American Factfinder (10516 + 10524 Zip Codes)
Total Philipstown commercial square footage (from Town Assessor's Office) = 2,395,000 ft2
2,395,000 ft2 / 275 commercial sites = 8,709 ft2 / site
2,395,000 / 1904 workers = 1,258 ft2 / worker
Total workers in NYS = 8,178,455 (2016 County Business Patterns - American Factfinder)
Mean square feet per worker (National average since we could not find a NYS average) = 936 ft2 / worker (2012 EIA Commercial Building Energy Consumption Survey)

PHILIPSTOWN INVENTORY REPORT | 2020 | APPENDIX A

Total NYS commercial square footage = 8,178,455 workers x 936 ft2 / worker = 7,655,033,880 ft2
Then, since no local data was available on fuel use percentages for Philipstown, we used the same percentages from the 2016 American Community Survey for household fuel use to calculate the commercial square footage for Philipstown wood usage. NYS Fuel Usage Statistics came from the 2012 EIA Commercial Sector Energy Consumption Estimates.

NYS SF Wood = 7,655,033,880 x .02 Wood (ACS Fuel %) = 153,100,678 ft2
Philipstown SF Wood = 2,395,000 ft2 x .046 Wood (ACS Fuel %) = 110,170 ft2
Commercial Wood Use Philipstown = 7,900,000,000,000 BTU / 1,000,000 MMBTU/ Trillion BTU x (110,170 x 5517) / (153,100,678 x 5642) = 5,559 MMBTU

This total was then entered into ICLEI's ClearPath calculator to convert the amount of wood used into GHG emissions. The same was done for each of the following heating fuel sources. In the case of wood, however, emissions were not initially completed due to lack of a wood fuel option within the ClearPath calculator for commercial stationary combustion. An estimate was made using the residential stationary combustion calculator for wood and results were entered as "direct entry in the commercial sector. All other fuel uses were available in both the residential and commercial emissions sections of the ClearPath tool.

IV. Propane
We used the same methods to calculate propane usage as described above with wood, except we inserted propane usage data from the 2016 ACS and 2016 EIA Fuel Use Data for both residential and commercial.

Residential:
NYS HUadj Propane = 261,912 x 0.7255 = 190,017
Philipstown HUadj Propane = 251 x 0.9108 = 229
Propane Use Philipstown = 5,529,000 barrels x 42 gallons/barrel x (229 x 5517) / (190,017 x 5642) = 273,658 gallons

Commercial:
NYS SF Propane = 7,655,033,880 x .036 Propane (2016 ACS Fuel %) = 275,581,220 ft2
Philipstown SF Propane= 2,395,000 ft2 x .07 (2016 ACS Fuel %) = 167,650 ft2
Commercial Propane Use Philipstown = 2,061,000 barrels x 42 gallons / barrel (167,650 x 5517) / (275,581,220 x 5642) = 51,493 gallons

V. Heating oil and kerosene
We used the same methods to calculate heating oil and kerosene usage as described above with wood, except we inserted heating oil and kerosene usage data from the 2016 ACS and 2016 EIA Fuel Use Data. Furthermore, because the American Community Survey combines data for heating oil and kerosene into a single percentage and also includes a category for "other fuel," we combined heating oil, kerosene and other fuel so as to include the percentages of each in the calculations, and then separated heating oil and kerosene at the end. Since we didn't have information on what the "other fuel" is, in order to not overlook it, we considered it as either heating oil or kerosene.

NYS Heating Oil Consumption = 15,511,00 barrels
NYS Kerosene Consumption = 602,000 barrels
Percentage Heating Oil vs Kerosene based on above NYS consumption usage:
Heating Oil = 96.26 % and Kerosene = 3.74%
State HUadj Heating Oil + Kerosene = 1,732,065 x 0.7255 = 1,256,613
State HUadj Heating Oil = 1,209,616
State HUadj Kerosene = 46,997
Philipstown HUadj Oil + Kerosene = 2847 (74.4% heating + 3.4% kerosene + 1.2% other fuel = 79% or 2847 Housing Units) x 0.9108 = 2593
Philipstown HUadj Heating Oil = 2593 x 0.9626 = 2496
Philipstown HUadj Kerosene = 2593 x 0.0374 = 97
Oil Use Philipstown = 15,511,000 barrels (Oil Use State) x 42 gallons/barrel x (2593 (Philipstown HUadj Oil) x 5517 (local HDD)) / (1,209,616 (State HUadj Oil) x 5642 (state HDD))
= 1,365,570 gallons
Kerosene Use Philipstown = 602,000 barrels x 42 gallons/barrel x (97 x 5517) / (46,997 x 5642) = 51,029 gallons

For commercial use, we used the same methods to calculate heating oil and kerosene usage as described above, except we inserted heating oil and kerosene usage data from the 2016 ACS and 2016 EIA Commercial Fuel Use Data. Furthermore, because the American

Community Survey combines data for heating oil and kerosene into a single percentage and also includes a category for "other fuel," we combined heating oil, kerosene and other fuel so as to include the percentages of each in the calculations, and then separated heating oil and kerosene at the end. Since we didn't have information on what the "other fuel" is, in order to not overlook it, we considered it as either heating oil or kerosene.

Philipstown SF Heating Oil + Kerosene = 2,395,000 ft2 x 0.79 Heating Oil / Kerosene / OtherFuel (2016 ACS Household Fuel %) = 1,892,050 ft2
Percentage Heating Oil vs Kerosene based on above NYS consumption usage:
Heating Oil = 96.26 % and Kerosene = 3.74%
Philipstown SF Heating Oil = 1,892,050 ft2 x .9626 = 1,821,287 ft2 of space - Heating Oil
Philipstown SF Kerosene = 1,892,050 ft2 x .0374 = 70,763 ft2 of space - Kerosene
NYS SF Heating OIl + Kerosene = 7,655,033,880 x .238 Heating Oil/Kerosene (2016 ACS Household Fuel %) = 1,821,898,063 ft2
NYS SF Heating Oil = 1,821,898,063 ft2 x .9626 = 1,753,759,076 ft2 of space - Heating Oil
NYS SF Kerosene = 1,821,898,063 ft2 x .0374 = 68,138,988 ft2 of space - Kerosene
Commercial Oil Use Philipstown = 8,095,000 barrels oil x 42 gallons / barrel x (1,821,287 x 5517) / (1,753,759,076 x 5642) = 345,259 gallons
Commercial Kerosene Use Philipstown = 57,000 barrels kerosene x 42 gallons / barrel (70,763 x 5517) / (68,138,988 x 5642) = 2431 gallons

Alternative Approach: Compare number of oil customers at state vs local to get a better ratio to calculate oil... we tried obtaining local customer numbers but were turned down by most local companies, so we decided to take the above approach.

Industrial Energy
There are no sites that are classified as industrial within Philipstown, according to both the EPA's Greenhouse Gas Reporting Program and the NYSDEC's Title V Air Permit Data Set, although there are several "light industry" businesses within Philipstown, which were accounted for in the Commercial Energy section above.

Solid Waste

I. Collection and Transportation Emissions
For the Village of Cold Spring we received municipal data on total mass of solid waste, truck fuel type (diesel) and round-trip mileage for residential, commercial and municipal collection and transportation of solid waste to Wheelabrator Solid Waste Incineration Facility in Peekskill, NY (25 miles). With this information we were able to use ClearPath to calculate total collection and transportation emissions. However, for the rest of Philipstown, which is served by two private companies that declined to share their data, we had to use the following approach:

Based on the 2010 Mid-Hudson GHG Emissions Inventory Average Municipal Solid Waste data for Putnam County: 4.9 lb / person / day x 365.25 days = 1789.725 lb / person / year x 7,724 people (non-Cold Spring population of Philipstown) = 13,823,835.9 lb / year / 2,000 lb / short ton = 6,911.91795 short tons / year (which is the metric we needed to enter into ClearPath). The average round-trip transportation route (estimated from the center of Philipstown to Royal Carting Transfer Station in Fishkill, NY and then to Dutchess County Resource Recovery Agency in Poughkeepsie, NY was 50 miles, which we entered directly into the ClearPath Tool to calculate transportation emissions.

II. Combustion of Solid Waste
As described above, total tons of solid waste was obtained from records just for the Village of Cold Spring, whose waste is sent to Wheelabrator Facility in Westchester for electricity-generating incineration. The rest of Philipstown is covered by two private companies that declined to share their data, so we used the same total solid waste that we calculated above for the remainder of Philipstown.

III. Composting
To calculate the total mass of composted solid waste in Philipstown we used the following approach using data from the EPA's "National Overview: Facts and Figures About Materials, Waste and Recycling." 2015 National Compost Generation: 23.4 million tons / 316,515,012 people (United States population - 2015 ACS) = 0.07393 tons/person x 9695 people (in Philipstown in 2016 according to ACS) = 716.75 tons of compost total.

Water and Wastewater

I. Nitrification-Denitrification Process
Philipstown has one in-boundary wastewater treatment plant, which is located in and managed by the Village of Cold Spring. Although the plant does not use nitrification or denitrification to treat the water, there can still be a small amount of nitrous oxide emissions related to the size of the population served, so in order to calculate emissions from nitrification / denitrification we used the population-based method in ClearPath and added an Industrial / Commercial Discharge Multiplier of 1.25 since the plant also serves commercial facilities within the village (based on the suggested multiplier in the ClearPath tool).

II. Effluent Discharge
Similarly to above, we used the population-based ClearPath method to calculate Nitrous Oxide emissions from effluent discharge from the predominantly aerobic-based treatment system. We also applied the 1.25 Industrial / Commercial Discharge Multiplier as described above.

III. Combustion of Biosolids and Sludge
To calculate the emissions from the combustion of biosolids and sludge from the Cold Spring Wastewater Treatment Plant, which first has its biosolids and sludge trucked to a facility in Beacon, NY, where it is dried and the water content is reduced by 7.5%, and is then trucked to New Jersey for incineration, we first assumed the energy content of dry biosolids to be 8,000 BTU/lb (Renewable Energy Resources: Banking on Biosolids, Page 3, National Association of Clean Water Agencies 2010). Then we gathered data from the treatment plant on the total gallons of sludge trucked to Beacon, and used the NYSDEC's *Converting Gallons of Sludge to Metric Tons* guide to calculate the daily metric tons of dry biosolids.

Dry biosolids average energy = 8,000 BTU / lb x 2204.62 lb / MT = 17.636960 MMBTU / MT

Sludge hauled at 2.5% biosolids = 155,000 gal x 8.34 lb/gal = 1,292,700 lbs x 0.025 (averaging 2-3% to 2.5%) = 32,317.5 lbs dry sludge / 2204.62 lb / MT = 14.65899 MT / year / 365.25 days / year = 0.04013 MT / day

To calculate emissions from the transport of biosolids and sludge, we determined from the treatment plant and the intermediate plant in Beacon the total number of trips per year, the biosolids + sludge tank capacity of each truck, the roundtrip mileage for each trip, and the mileage per gallon of diesel fuel for each truck.

Wastewater Transportation:

155,000 gallons / 7,500 gallons per trip to EarthCare in Beacon = 21 trips x 14.2 miles roundtrip / trip = 298.2 miles / 4.5 miles / gallon diesel truck fuel efficiency = 66.27 gallons diesel from Cold Spring to Beacon
Waste evaporated from 2.5% to 9% concentration = 2.5 x 91% / 9% = 25.28, so if 155,000 gallons x 2.5 % = 3875 gallons, then 3875 x 25.28 / 2.5 = 43,834 gallons at 9% biosolids
From Beacon to NW Bergen County Wastewater Treatment Plant: 43,834 gallons / 6500 gallons / trip = 7 trips x 94.8 miles roundtrip / trip = 663.6 miles / 4.5 miles / gallon diesel = 147.47 gallons diesel
Total diesel usage per year = 66.27 + 147.47 = 213.74 gallons diesel

IV. Septic Systems
We used the population-based ClearPath method to calculate septic emissions for residents and businesses within Philipstown that are not served by the Cold Spring Wastewater Treatment Plant (9,695 - 1,971 = 7,724 population with septic tanks).

Agriculture

I. Enteric Fermentation
Since some Philipstown-scale data was not easily available, to determine agroforestry and land-use emissions, we first obtained cropland acreage, pasture acreage and livestock data from both the 2012 Census of Agriculture for NYS and Putnam County and created pasture and cropland ratios to compare Philipstown to NYS and to Putnam County. We then gathered land use data for Philipstown from NASS GeoData CropScape 2016. Lastly, we used the EPA's State Inventory Tool (SIT) to calculate emissions from enteric fermentation by entering information on cows, horses, sheep, hogs, and goats.

Total Philipstown cropland area: 187.7 acres
Total Philipstown pasture area: 254 acres
Putnam County cropland area = 689.2 acres

Putnam County pasture area = 2227.3 acres
NYS cropland area: 4,329,215.3 acres
NYS pasture area: 1,926,695.6 acres
Philipstown to Putnam cropland ratio = 0.2723
Philipstown to Putnam pasture ratio = 0.1140
Total Philipstown to Putnam farmed land ratio = (441.7 / 2916.5) = 0.1515
Philipstown to NYS cropland ratio = 0.000043
Philipstown to NYS pasture ratio = 0.00013
Total Philipstown to NYS farmed land ratio = (441.7 / 6,255,910.6) = 0.0000706052
Putnam County Market Value of Ag. Products sold = $3,256,000
Philipstown Market Value of Ag. Products Sold = $3,256,000 x 0.1515 = $493,284
Dairy cows: 620,000 x .00013 = 81 (NYS data)
Beef cows: 185 - 81 = 104 (difference)
Total cattle: 1,419,365 x 0.00013 = 185 (NYS data)
Horses: 539 x .1140 = 61 (Putnam data)
Sheep: 133 x .1140 = 15 (Putnam data)
Hogs = 46,000 x 0.00013 = 6 (NYS data)
Goats = 29,300 x 0.00013 = 4 (NYS data)
Total farmed area = 441.7 acres

II. Fertilizer Application
To calculate emissions from fertilizer application we used the following method: USDA's National Agricultural Statistics Service (NASS) lists a total of $28,000 spent on synthetic fertilizer in Putnam in 2012 (Putnam County Profile). We then applied the Philipstown to Putnam County Cropland Ratio from above to calculate Total Philipstown Fertilizer Expenses and entered this data into EPA's State Inventory Tool (SIT) to calculate emissions.

Total Philipstown Fertilizer Expenses: = $28,000 x 0.2723 = $7624 spent on fertilizer / $537 average cost in 2012 per ton of nitrogen fertilizer** = 14.97917 short tons of synthetic fertilizer x 907.185 kg / short ton = 13,589 kg of synthetic fertilizer

III. Manure Treatment and Handling
We entered all of the above data on cows, horses, sheep, hogs and goats into the EPA's State Inventory Tool (SIT) to calculate emissions from manure treatment and handling.

Process and Fugitive Emissions

Ozone-Depleting Substance (ODS) Replacement Emissions
To calculate emissions from substances that have been used to replace Ozone-Depleting Substances, we drew on data from the National ODS Replacement Emissions Data Source: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016 – Industrial Processes and Product Use - Table 4-1. From this data we found that National ODS Replacement Emissions = 159,100,000 MTCO2e / 318,558,162 (National Population - 2016 ACS) = 0.4994 MTCOe / person, and multiplied this by the 2016 population of Philipstown.

Philipstown ODS Replacement Emissions = 9695 people x 0.4994 MTCOe / person = 4842 MTCO2e

Upstream Impacts & Activities

I. Residential and Commercial SF6 Emissions from Transmission and Distribution
To calculate the emissions from the leakage of the greenhouse gas Sulphur Hexafluoride (SF6) from electricity transmission and distribution lines we used the following method: SF6 Transmission and Distribution factor = 4,300,000 MTCO2e (Total National SF6 Emissions*) / 3,762,461,630 MWh (Total National Electricity Sales) = 0.0011 MCO2e SF6 Emissions / MWh. Then we multiplied this factor by the electricity used in Philipstown in both residential and commercial buildings and facilities to calculate the SF6 transmission and distribution emissions.

Residential: 38,400.9 MWh x 0.0011 = 42 MTCO2e

Commercial: 12,648.34 x 0.0011 = 13 MTCO2e

PHILIPSTOWN INVENTORY REPORT | 2020 | APPENDIX A

*From the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016 - Industrial Processes and Product Use - Table 4-105: SF6 Emissions from Electric Power Systems and Electrical Equipment Manufacturers

II. Commercial and Residential Grid Loss
To calculate emissions from grid loss for both commercial and residential electricity use, we applied the grid loss factor from the Emissions and Generation Resource Integrated Database (eGRID), and selected the Upstate NY (NYUP) grid, of which Central Hudson Gas & Electric is a part. We then entered this grid-loss factor as well as the amount of commercial and residential electricity used in Philipstown into the ClearPath tool to calculate total grid-loss emissions.

Town of Philipstown Government Operations Emissions
The Town of Philipstown has conducted its own government operations emissions inventory, which will be released as a separate report.

Philipstown Consumption-Based GHG Inventory Methods

Consumption-Based Accounting: Data sources and collection
As indicated above, we utilized the ICLEI ClearPath Tool and the Berkeley CoolClimate Calculator Tool to guide our data collection for consumption-based accounting. The sectors we included in our consumption-based accounting were the following:

- On-road transportation, including car usage, commuting behavior;
- Air travel;
- Household management, including home renovations and landscaping/property management activities;
- Food consumption, including types of foods, servings and where purchased;
- Other household goods consumed, including clothing, furniture, cell phones, appliances and where these items are purchased;
- Stationary energy, including home heating fuel and solar array installations;
- Services consumption, including health care, education and entertainment & recreation.

While these two online tools suggested important variables to collect data on, they relied heavily on national- or state-level estimators, as well as per capita income comparisons, to convert goods and services consumption behaviors into GHG emissions estimates. We decided that collecting actual Philipstown resident data would provide us with more accurate and reliable consumption information for our Town's estimates on the variables that we determined to be most important and actionable. In addition, the local data provides a baseline against which a future survey could identify changes in consumption and associated emissions changes.

Through a short series of meetings with Task Force members and key stakeholders, we identified key variables to include in our consumption inventory, as well as ranked the variables we felt were most important to collect local data on because it was most likely to inform our intervention efforts in the near future. An example of such variables were household lawn/property maintenance practices. Task Force members were concerned both with the types of tools used to maintain properties, as well as the amendments or products being applied to turf/lawns. Another example of such a variable would be refrigerant disposal practices because our Task Force is currently working on an initiative for safe disposal of appliances with refrigerants given that associated chemicals have some of the most potent GHG effects in our atmosphere.

Table A1: Measures matrix for Philipstown Community Survey, 2019.

CONSUMPTION CATEGORY	MEASURE
On-road vehicle emissions	Vehicle ownership/leaseholder Number of vehicles Fuel type Year of vehicle Miles driven (annual) Fuel efficiency
Commuting behavior	What transit use to commute Commute round-trip (weekly)
Air travel	Short, medium and long-haul trips (annual)
Household renovations	Lumber Concrete
Landscaping/property management	Gas-powered tool use Non-organic application use Organic application use Acreage of property managed
Food consumption	Household vegetarians/vegans Meat consumption (per day) Type of meat consumed (%) Where purchase meat Dairy consumption (per day) Where purchase dairy Vegetable/fruit consumption (per day) Where purchase produce Snack food consumption (per day) Where purchase snack foods Household food waste (%) Where food waste goes
Other household goods consumption	Clothing consumption ($/year) Appliance consumption ($/year) Furniture consumption ($/year) Purchase history of used clothing/appliance/furniture Where purchase various household goods (food, personal care products, cleaning products, home improvement products, gifts) Cell phone purchase and disposal history Refrigerator/freezer purchase and disposal history Air conditioning unit purchase and disposal history Carbon offset purchase history
Stationary energy	Solar array installation Home heating fuel/source
Household demographics	Square footage of home Owner/renter % of calendar year in Philipstown home Household size Household income Household tenure in Philipstown Age of respondent Education of respondent Gender identity of respondent
Climate change attitudes	Adapted from Christensen & Knezek (2015): The Climate Change Attitude Survey, International Journal of Environmental & Science Education, 1-(5), 773-788.
Respondent contact information	Name, address (to verify residency in Philipstown) Email/Phone (optional)

PHILIPSTOWN INVENTORY REPORT | 2020 | APPENDIX A

A sub-committee of the Task Force worked with consultant-partners, ICLEI, to create a household survey that was made available to every household within Philipstown. We used questions already used in practice for most standard variables. Questions that had to be designed for purposes specific to this community survey were developed by a trained survey researcher on the Task Force and reviewed by a panel of experts at ICLEI. A full list of the variables included in the household survey is in Table A1.

The household survey was made available online through a web-based Google form and was also available as a downloadable document on the Task Force website. A paper version of the survey was available at the two local libraries, the local senior center, and the Town Hall and Village Halls. We conducted outreach with the three local schools to encourage families to participate in the survey, as well as conducted outreach with local businesses through the Chamber of Commerce and with local non-profit or civic organizations, asking them to encourage their members to participate. We also created a postcard mailer that was mailed to every household in Philipstown reminding them to participate in the survey (Appendix D).

Only persons 18 years or older and who are residents (full or part-time) of Philipstown were eligible to complete the survey. We collected basic demographic information, as well as name and address to verify residency. All responses were kept in a password-protected file that only the survey developer had access to and the data was de-identified once addresses were verified so that all responses are confidential and are used only in the aggregate. The paper-based survey is available from the authors upon request.

Consumption-Based Accounting: Calculations
The household survey provided data on types and amounts of consumption by community residents. This data was combined with emissions factors, usually derived from nationally-recognized data sources, to calculate consumption-based emissions.

Car travel: The vehicle miles and miles-per-gallon data from the survey allowed calculation of gallons of fuel used and direct fuel emissions using the same emissions factor as the production inventory. In addition, the consumption inventory includes upstream emissions from fuel production of 1.6kg CO2e/gallon, and vehicle manufacturing emissions of 58 gCO2e/mile.

Air travel: Average air passenger miles per household were calculated from the survey data using the midpoint of each flight length category. For flights over 2300 miles, the assumed average length was 3500 miles. Factors for emissions per passenger mile based on each flight type (short, medium or long) were used to calculate emissions.

Home heating: Heating fuel usage reported on the survey was multiplied by the direct emissions factors used in the production based inventory. In addition, upstream fuel production emissions of 1.62 kg/gal for heating oil and 1.16 kg/gal for propane were included. Because data is not available on electricity use specific to heating, households using electric baseboard, heat pump or geothermal were assumed to require the same average heat input as households using oil or propane. The heat requirement was converted to kWh using an efficiency of 3.4 btu/kWh for baseboard, 8 btu/kWh for heat pumps, and 11.9 btu/kWh for geothermal heat pumps. In addition, the calculation assumes an 80% efficiency for fuel combustion equipment (oil or propane).

Electricity use: Average per household residential electricity use from the production based inventory was used. The estimated electricity use for heating (as described above) was subtracted to calculate 'other electricity use.' A life cycle electricity emissions factor was calculated using the Central Hudson generation mix, and life cycle factors for each generation type from NREL. The resulting emissions factor of 542.11 lbs CO2e/MWh is about 4% higher than the direct emissions factor used in the production based inventory.

GENERATION SOURCE	COAL	NATURAL GAS	NUCLEAR	HYDRO	WIND	SOLAR
gCO2e/kWh	980	470	10	5	11	45

Home construction: Emissions associated with home construction were calculated using the average square footage reported in the survey and an emissions factor of 0.93 kg CO2/square foot, based on emissions to produce construction materials spread over a 50 year lifetime of the building (while the basic structure may last longer, many materials such as roofing and carpet will be replaced more frequently).

Food: The servings per person reported through the survey were converted to grams and multiplied by the number of people in each household. These were then multiplied by per gram emissions factors for food production. The survey did not ask about grain consumption, so grain consumption per person from USDA data was used.

FOOD TYPE	BEEF	PORK	CHICKEN	FISH
gCO2e/g food	82.1	5.6	8.9	6.2
FOOD TYPE	DAIRY	VEGETABLES	SNACK FOODS	GRAINS
gCO2e/g food	4.3	1.3	13.1	5.1

Emissions factors for most foods were drawn from (Jones and Kammen 2015). Because that study did not include individual factors for beef and pork, the factors for those are drawn from a WRI report. Emissions factors for other food types are roughly similar between the WRI report and (Jones and Kammen 2015). It is worth noting that the WRI report uses a model that accounts for land-use change as well as agricultural production emissions.

Goods and services: The survey provided data on consumption of clothing, and on furniture and appliances. Emissions were calculated using emissions per dollar spent.

GOODS TYPE	CLOTHING	APPLIANCES	FURNITURE
Emissions (gCO2e/$)	750	614	614

For other goods and for services (which the household survey did not collect data on), emissions were calculated using the Berkeley Cool Climate household calculator with household income set to $100,000; these emissions were then multiplied by 1.08 to scale to $108,000/year, median household income for Philipstown in 2017.

Philipstown Land Use Inventory Methods

Carbon Storage and Sequestration: Data sources and Collection
Philipstown is rich in natural resources and has over three-quarters of its land covered in deciduous and evergreen forest. Land use decisions have potential to influence a municipality's carbon storage and sequestration, so we set out to understand a baseline of how our Town's land was classified. We referred to several online databases and local land experts, researchers and non-governmental organizations to create a map of Philipstown.

In March 2019, we organized a convening for leaders of local organizations already invested and participating in measuring carbon storage or sequestration. Following this initial discussion of experts, we began mapping land use by acreage within Philipstown, identifying the following land use categories as critical for understanding carbon storage and sequestration: forests (including deciduous, evergreen and mixed); wetlands (including estuarine/marine deepwater, lakes and ponds, riverines, freshwater woody/forested wetlands, freshwater emergent wetland, estuarine/marine wetlands); grasslands (including developed open space [i.e., turf/lawns], managed pasture/hay and unmanaged pasture/hay); agricultural lands (including cultivated annual and perennial crops); and barren or impervious areas. We also included a way to compare land use categorizations by identified protected areas, conserved areas, zoning categories and tax parcels, which will be useful for future development, conservation and climate mitigation activities.

We used a variety of datasets to create GIS layers for Philipstown, which also provided estimates of area or acreage for the various land categories. The two primary databases we used were the National Land Cover Database (NLCD) and the National Wetlands Inventory (NWI). Additional datasets were also utilized. We worked with two GIS experts to procure clipped data for Philipstown, store data that requires server space and to create a searchable PDF document that allows users to select different layers to investigate land features. This map includes a satellite image from Google Earth as a base layer. The area or acreage of the various land use categories could then be calculated using the GIS shapefile attribute tables (Table A2).

PHILIPSTOWN INVENTORY REPORT | 2020 | APPENDIX A

Table A2. Land use/cover databases utilized in this inventory.

DATABASE	YEAR(S)	HOW ACQUIRED	LAND USE CATEGORIES
National Land Cover Database	2001; 2016; and change in land use	Public Use	Open water Woody wetlands Emergent herbaceous wetlands (i.e., marshes)
	2001-2016	Public Use	Developed, open space (e.g., lawns, parks, golf courses) Developed, impervious (e.g., buildings, structures, roads) Barren (rock/sand/clay; vegetation <15%) Forest, deciduous (>75% deciduous trees) Forest, evergreen (>75% evergreen trees) Forest, Mixed (neither deciduous nor evergreen are >75%) Shrub/scrub Grasslands/herbaceous Pasture/hay Cultivated crops
National Wetlands Inventory	2019	Public Use	Estuarine and marine deepwater (i.e., open water) Estuarine and marine wetland (i.e., emergent herbaceous wetland) Freshwater emergent wetland (i.e., emergent herbaceous wetland) Freshwater forested/shrub wetland (i.e., woody wetlands) Freshwater pond (i.e., open water) Lake (i.e., open water) Riverine
New York Protected Areas Database	2019	Public Use	Boundaries of protected areas, including fee-owned properties and easements
National Conservation Easement Database	2018	Public Use	Boundaries of easement properties; note that these properties are not public land
Cropland	2016	Public Use	Cultivated crops grown in Philipstown: Alfalfa, Apple, Christmas trees, Corn, Fallow/idle cropland, Grass/pasture, Oats, Other hay/non-alfalfa, Pears, Rye, Soybeans, Winter wheat
Putnam County Zoning	2018	Acquired from county	Highway commercial district Hamlet mixed use district Hamlet residential Institutional conservation Industrial manufacturing Office commercial/industrial Resource conservation district Rural residential Suburban residential
Putnam County Tax Parcels	2018	Acquired from county	Boundaries and identification of tax parcels
Putnam County Agricultural Districts	2019	Acquired from county	Same as NLCD designations

Each database analysis resulted in slightly different acreages for the various land use types, so we selected the most valid estimates depending on land use category. For forested acreage, we prioritized the NLCD's acreage estimates. For water body or wetlands acreage, we prioritized the National Wetland Inventory. For agricultural acreage, we prioritized Putnam County Agricultural Districts and Cropland databases. For impervious or barren acreage, we prioritized the NLCD's estimates. We also examined the change in land use categorization from 2001 to 2016 using an available NLCD dataset to estimate if changes were emitting (e.g., forested land converted to developed space) or storing/sinking (e.g., grassland planted to orchard or forest).

Carbon Storage and Sequestration: Calculations
In order to estimate carbon storage and sequestration of Philipstown's different land use categories, we utilized size of land use type and a "carbon multiplier" (Table A3). Specifically, we worked with experts in the field to select the most valid carbon multipliers by land use type for:

- Carbon storage - the amount of carbon bound up in carbon pools, usually in the form of biomass (aboveground and belowground living matter), and also includes dead organic matter, soil organic carbon and carbon in harvested wood products, also referred to as carbon stock; and
- Carbon sequestration - the removal of carbon from the atmosphere per year through the process of photosynthesis, also referred to as carbon sinking.

For example, forests absorb carbon from the atmosphere (in the form of carbon dioxide) and store it in carbon pools in the form of biomass, such as in aboveground trees, root systems, undergrowth, forest floor and soils. The annual absorption is referred to as the sequestration rate, which is dependent on many external factors. As these carbon pools increase in size or density, they store more carbon. When these carbon pools decompose or are burned, they release carbon (as carbon dioxide) back into the atmosphere. Other examples of carbon pools include wetland peat, grasslands (including turf, lawns, pastures, hayfields), croplands (including row crops and orchards), soil organic carbon and landfills.

I. Forests

For our forest carbon sequestration multiplier, we used a value of 696.7 gCO2e/m^2/year (190.02 g-C/m2/yr), retrieved from researchers at the Black Rock Forest Consortium (BRFC). The BRFC has been collecting data on carbon content and storage of various tree types in the Black Rock Forest for decades and recognizes this as the most appropriate carbon multiplier on average for mixed forests in the Mid-Hudson Valley region. This carbon multiplier value is then multiplied by the total forested area in Philipstown to arrive at an estimate of carbon sequestered annually in our forests' trees (i.e., aboveground biomass). Soil organic carbon on our forest floors are not included in our estimates of forest sequestration, so our forest estimate can be interpreted as a floor estimate: if we were to measure and include the carbon sequestering of our soil organic carbon in our forest floors, our total sequestration estimate would be significantly higher because soil also serves as a carbon sink.

II. Wetlands

Wetlands are net carbon pools (i.e., stocks): the amount of carbon they sequester in the form of soil organic carbon is greater than their net methane oxidation emissions (Mitsch et al. 2013), and in fact, wetlands hold between 20 and 30 percent of the global soil carbon pool, despite occupying 5-8% of the globe's land surface (Nahlik & Fennessy, 2016). The United States Geological Survey (USGS) Eastern US Carbon Storage Report recommends a wetlands carbon sequestration multiplier of 484.7 g-CO2e/m^2/year (132.2 g-C/m^2/yr). However, sequestration varies by wetland type. For example, Mitsch et al., (2013) found a sequestration rate of 454.7-586.7 g-CO2e/m^2/year (124-160 g-C/m^2/yr) in temperate flow-through wetlands, and ultimately recommended an average multiplier of 432.7 g-CO2e/m^2/year (118 g-C/m^2/yr), cautioning that most carbon retention occurs in tropical/subtropical wetlands. Craft (2007) found sequestration rates for freshwater, brackish and tidal marshes, ranging from 440-990 +/- 73 g-CO2e/m^2/year (140+/-20 g-C/m^2/yr). Turunen et al. (2002) found a sequestration rate of 36.7-168.7 g-CO2e/m^2/year (10-46 g-C/m^2/yr) in temperate North American peatlands. Still another (Mitra et al., 2005) provides a general range for wetlands of 73.3-513.3 g-CO2e/m^2/year (20-140 g-C/m^2/yr). Our local wetland experts at Lamont-Doherty Earth Observatory recommend using the 2018 State of the Carbon Cycle Report which suggests 143-781 g-CO2e/m^2/year (39-213 g-C/m^2/yr) for general wetland sequestration.

Therefore, we will utilize the range of 143-781 g-CO2e/m^2/year (39-213 g-C/m^2/yr) as our sequestration estimate for ponds and freshwater emergent herbaceous wetlands and we will utilize the range of 440-990 g-CO2e/m^2/year (120-270 g-C/m^2/yr) for our tidal wetland/marshes. We recognize that these multipliers vary year-to-year and by wetland type, so any sequestration estimates are only approximations and have high levels of uncertainty.

According to US National Inventory and US Community Protocol, Appendix J, woody wetlands should be classified as forest and therefore have the mixed forest multiplier applied: 696.7 g-CO2e/m^2/yr (190.02 g-C/m^2/yr).

For our wetlands carbon storage multiplier, we referred to a local wetland expert and researcher from Lamont-Doherty Earth Observatory, who has been coring and analyzing wetland peat in the Hudson Valley. The formula for estimating carbon (C) storage in wetlands is

C stored = C content X area of wetland X average peat depth

whereas,

C content = % organic matter loss-on-ignition (LOI) X bulk density X average amount of C in sedge peat

PHILIPSTOWN INVENTORY REPORT | 2020 | APPENDIX A

Researchers from Lamont-Doherty supplied us with average loss-on-ignition (LOI), bulk density and amount of carbon in sedge peat from their research in Constitution Marsh and Sutherland Pond and Fen in Black Rock Forest. We caution that there is significant variability in both LOI and bulk density depending on how deep the sample is taken. For example, a core sample near the surface of the peat has a higher LOI and bulk density than a core sample near the bottom of the peat. This is a function of age: a sample near the surface is younger in years and therefore has more organic matter that is burned off during the LOI measurement process. Another example: samples could have high bulk density, but rather than being a result of high organic matter (i.e., carbon) it could be a result of a high concentration of sand or silt. This variability led to a range in carbon content calculated.

To obtain "average peat depth" a small group of Task Force volunteers took to the wetlands with probing sticks to collect actual data on peat depth (Appendix C). We selected 2 of each of the 4 wetland types in our Town (8 sampling sites in total) and probed 7 random sample spots in at each site by inserting probing sticks into the "muck" as far as we could until the sticks reached firm resistance. We then averaged the 7 sample depths for each site and used these as estimates of "average peat depth." Given the high variability in many of these variables which are dependent on wetland type, wetland volume, age of wetland, annual weather patterns, we calculated a range for storage: 6,000 - 69,000 g-C/m^3 (which must be multiplied by an average depth of the wetland peat). We totaled the average area of our wetland types (estuarine/marine wetland [i.e., marshes], woody wetland, emergent herbaceous wetland, and freshwater pond/lakes) from our NWI data and then multiplied that area by the carbon content range and peat depth. This range must be interpreted with caution.

III. Grasslands

Grasslands include developed open spaces, such as lawns, turf, golf courses and parks, as well as pasture or hay. Grasslands are net carbon storing/sequestering with different multipliers applied depending on how the land is managed and cultivated. Current research (Zirkle et al., 2011) on "turf" grass, which includes lawns, parks, golf courses and other developed open spaces, suggests a range of carbon sequestering potential. This includes average carbon accumulation in the form of biomass (i.e., net primary productivity, 5.89+/-1.26 to 12.71+/-2.30 Mg-C/ha per year) and in soil organic carbon dynamic accumulation (0.46+/-0.18 Mg-C/ha per year). The carbon multiplier value applied depends on how the land is managed and cultivated: how often it is mowed, to what length it is mowed, whether and what kind of fertilizers/pesticides/herbicides are applied, and how much it is irrigated, with a goal of maximizing growth above- and belowground as well as maximizing soil organic content. It also includes hidden carbon costs of using gas-powered equipment or fossil fuel-intensive fertilizers/pesticides/herbicides.

Therefore, we apply a range of multipliers according to:

- Minimal input lawns (i.e., mowing once a week without irrigation, fertilizer or pesticide use): 25.4-114.2 g-C/m^2/year,
- "Do-it-yourself" or medium input lawns (i.e., mowing once a week with some irrigation, fertilizer or pesticide inputs): 80.6-183.0 g-C/m^2/year; and
- Best management practice lawns (i.e., use of a lawn care service to engage in mowing and multiple fertilizer applications per year): 51.7-204.3 g-C/m^2/year.

This results in an overall range of 25.4 - 204.3 g-C/m^2/year. National estimates suggest 50 percent of turf is minimal input; 37.5 percent is medium input; and 12.5 percent is best-management practice (Zirkle et al., 2011), so we also applied these weights in calculations.

For unmanaged pasture/hay land use in Philipstown, we applied the multipliers for "minimal input lawns" and for managed grasslands (e.g., for grazing or otherwise) land use in Philipstown, we applied the "medium input" multipliers because they were "mowed" and fertilized by livestock.

For grassland carbon storage estimates, we used 4,200 g-C/m^2, as recommended by the USGS Eastern US Carbon Storage Report. However, we caution against use of this number given the high variability depending on management practices.

IV. Agricultural land

Agricultural land also has unique carbon storing/sequestering potential, depending on how the land is managed and cultivated. Conventional agricultural practices, which include monocropping, tilling soil, concentrated livestock grazing and application of inorganic fertilizers, pesticides, herbicides, can result in land that is a net carbon emitter. However, when regenerative agricultural practices are utilized, the land can be carbon storing/sequestering. Regenerative agriculture is a system of farming that increases biodiversity, improves soil health, improves watersheds and enhances ecosystem functioning. This includes practices such as diversified planting, perennial planting, no or minimal soil tillage, application of compost, cover cropping, and managed livestock grazing.

Carbon multipliers range from 12 -200 g-C/m^2/year, depending on these agricultural practices. According to Terra Genesis International, which promotes regenerative agricultural practices, annual cropping with compost and crop rotation can sequester 200 - 600 g-Carbon/n^2/year, compared with managed grazing (0-400 g-C), silvopasture (300 - 3,400 g-C), perennial crop planting (100 - 2,600 g-C) and agroforestry (300 - 4,100 g-C). For this reason, we report a range for carbon sequestration rate utilizing an estimate for conventionally cultivated (i.e., 12 g-C/m^2/yr) to minimally cover cropped/composted (i.e., 200 g-C/m^2/yr) and interpret results with caution.

For each regenerative practice that is applied to land, there is more carbon storing/sequestering potential. For example, in Philipstown an organic farm that applies annual compost, plants cover crops, and has a diversified crop plan will store less carbon than an organic farm that utilizes all of these practices plus does not till the soil. For carbon storage estimates we utilized 4,200 g-C/m^2, as recommended by the USGS Eastern U.S. Carbon Storage Report. However, we caution against use of this number given the high variability depending on agricultural practices.

V. Settlements and other land uses

"Settlements" consist of developed areas and impervious surfaces and "other land uses" consist of bare soil, rock and barren land. Because these land uses are largely devoid of biomass, soil organic carbon or other carbon pools, their areas are not included in carbon storage, sequestration or emission calculations.

Table A3. Carbon storage and sequestration multipliers by land use type.

LAND USE TYPE	CARBON STORAGE MULTIPLIER	CARBON SEQUESTRATION MULTIPLIER (G-C/M^2/ YEAR)	CARBON SEQUESTRATION MULTIPLIER (G-CO2E/M^2/ YEAR)
Forest (mixed)	N/A	190.0	696.7
Wetland (general: emergent herbaceous wetland; ponds)	6,000-69,000 g-C/m^3 <multiplied by> average peat depth (m)	39-213	143-781
Wetland (estuarine marshes)	6,000-69,000 g-C/m^3 <multiplied by> average peat depth (m)	120-270	440-990
Wetland (woody wetland)	6,000-69,000 g-C/m^3 <multiplied by> average peat depth (m)	190.0	696.7
Wetland (open Hudson River)	N/A	20.6	-75.5
Developed open space (e.g., lawns, golf courses, parks)	4,200 g-C/m^2	25.4-204.3	93.1-749.1
Grasslands (managed pasture/hay)	4,200 g-C/m^2	80.6-183	295.5-671.0
Grasslands (unmanaged pasture/hay)	4,200 g-C/m^2	25.4-114.2	93.1-418.7
Agriculture	4,200 g-C/m^2	12-200	44.0-733.3

VI. Land Use Change Between 2001 and 2016

According to the U.S. Community Protocol, conversions from forest land to other land uses results in net emissions of carbon, while conversions from non-forest land to forest land (i.e., afforestation or reforestation) result in sequestration of carbon. However, calculating changes in carbon stocks between land uses depends on multiple variables, including the forest strata, the non-forest land category, the area converted, the removal or emission factor (i.e., carbon multiplier) for each category, and the number of years since the conversion.

The NLCD provides data on land use changes from 2001 to 2016 in a single database. This database, however, does not indicate which direction the changes occur. We were able to estimate changes in acreage by land use type by subtracting the NLCD-reported acreage of each land use type in 2016 from the NLCD-reported acreage in 2001. We then estimated net emission/sequestration by applying our carbon multipliers to the acreage changes.

Appendix B: Town of Philipstown 2016 GHG Emissions Inventory Summary

GHG Emissions by energy source:

Energy Source	2016 MTCO2e	Energy Cost	%GHG	Cost per MTCO2e
Emp. Commute*	(62.42)	-	-	-
Electricity	89.36	$29,701	13%	$332.35
Fuel Oil	220.37	$29,572	32%	$134.19
Gasoline	175.60	$31,097	25%	$177.09
Diesel	207.99	$32,634	30%	$156.90
Propane	0.69	$218	0%	$316.51
Total:	**694.01**	**$123,222**	**100% $**	**178 (average)**

*Not included in Totals

GHG Emissions by facility:

FACILITY	METRIC TONS CO2e	TONS CO2e/ft^2	ENERGY COST
Recreation Center	161.95	7.85	$30,319
Highway Garage + Trailer	55.37	12.77	$12,555
Town Hall	42.46	8.80	$10,091
Depot Theater	24.86	24.86	$5,056
Aqueduct Rd Pump House	9.04	9.42	$5,117
CVPD Club House	8.26	3.30	$3,206
GLWD Pump House	4.95	51.56	$2,090
Highway Salt Shed	1.33	0.30	$833
CVPD Bath House	0.99	1.32	$732
Howland Dr Pump House	0.41	6.51	$574
Recycling Center	0.28	0.27	$542
Arden Dr Pump House	0.18	2.86	$508
Philipstown Park Welcome Sign	0.12	-	$344
CVPD Stone Barn	0.12	0.09	$366
CVPD Work Shop	0.09	0.10	$354

Appendix C: Wetlands probing data collection (2019).

In order to estimate carbon storage capacity of Philipstown's wetlands, volunteers put on their muck boots and got out their kayaks and went out to probe the depths of some of our wetlands. (Methods explained in the Methods Appendix).

Average probing depths for each wetland category sampled in Philipstown are listed in Table C1. Note that there is a large range of peat/muck depth, even within each category, which suggests that a wetland's value as a carbon storage stock depends highly on the specific wetland. We were unable to calculate carbon stored in our forests and grasslands because we did not have comparable soil organic carbon depth measurements.

Table C1. Wetland probing results in Philipstown (2019)

WETLAND TYPE	WETLAND NAME	AVG. PEAT/MUCK DEPTH (in)*
Estuarine/marine wetland	Constitution Marsh	720
	Manitou Marsh	265.6
Freshwater emergent wetland	Appalachian boardwalk (Route 9/403 intersection)	25.3
	S. Mountain Pass Spur	9.1
Freshwater forested/shrub wetland	Appalachian forest (north of 9/403 intersection)	16.4
	Secor St.	14.6
Freshwater pond/lake	403 pond (south)	356
	James Pond	17.3

*The peat/muck depth for Constitution Marsh was acquired from the Executive Director of the Marsh. All other average depths were sampled by volunteers.